Progress Report of a joint Project on
"Monitoring and Mapping of Forest Fires Across North America from Long-term AVHRR Archive"

In the past funding period, we have made significant progress in our project. Major findings related to our project which emphasize on methodology development and evaluation are documented in the following journal articles. Note that we also made contributions to papers led by other co-investigators (I. Csiszar, P. Gong). Since they submit separate progress report (I assume), these papers are not included here.

Li, Z., R. Fraser, J. Jin, Abuelgasim, I. Csiszar, G. Peng, R. Pu, W. Hao, 2002, Evaluation of Satellite-based Algorithms for Detection and Mapping Forest Fires within North America, J. Geophy. Res., revised.

This paper presents an evaluation of AVHRR-based remote sensing algorithms for detecting active vegetation fires [*Li et al. 2000a*] and mapping burned areas [*Fraser et al. 2000*] throughout North America. The procedures were originally designed for application in Canada with AVHRR data from the NOAA-14 satellite. They were tested here with both NOAA-11 and NOAA-14 imagery covering the period 1989-2000. It was found that the active fire detection algorithm performs well with low commission and omission error rates over forested regions in the absence of cloud cover. Moderate errors were found over semi-arid areas covered under thin clouds, as well as along rivers and around lakes observed from sun-glint angles. A modification to one of the algorithm's thresholds and addition of a new test can significantly improve the detection accuracy. Burned areas mapped using satellite data were compared against extensive fire survey data acquired by US forest agencies in five western states. The satellite-based mapping matches nearly 90% of total forested burned area, with the difference being mainly attributable to omission of some non-burned islands within the fire polygons. In addition, it maps areas of burning outside the fire polygons that appear to be true fires. The 10% omission error was related mainly to three factors: lack or insufficient number of active fires, partial burning, and vegetation recovery after early-season burning. In addition to total area, the location and boundaries of burn scars are consistent with the ground-based maps. Overall, the two algorithms are competent for detecting and mapping forest fires in North America (NA) north of Mexico (hereafter referred to as NA) with minor modifications.

Trishchenko, A., G. Fedosejevs, Z. Li, J. Cihlar, 2002, Trends and uncertainties in thermal calibration of the AVHRR radiometers onboard NOAA-9 to –16, *Rem. Sens. Environ.*, in press.

Satellite measurements from the infrared (IR) bands of AVHRR/NOAA have been used to detect fires and to derive many important atmospheric, cloud and surface parameters for assisting weather prediction, climate modeling and a variety of environmental studies. Calibration accuracy of the satellite data directly affects the accuracies of fire detection and the derived parameters. So far, very limited studies have been devoted to investigating the calibration uncertainties of the IR bands. In this study, we analysed the calibration data of AVHRR radiometers aboard polar orbiting satellites NOAA-9 to NOAA-16. The IR channels 3B, 4 and 5 are calibrated in-flight. Calibration coefficients were derived from measurements of radiance emitted from an internal calibration target (ICT) and the deep-space (SP). The overall budget of uncertainties is evaluated using observations of an in-flight calibration system that includes four thermal platinum resistance thermometers (PRT) to monitor the ICT temperature. The measurement noise (NEΔT) varies from 0.03 K to 0.3 K at 300 K depending on the channel and radiometer. It increases significantly as temperature decreases. Systematic degradation of the sensitivity of the IR sensors was detected during the lifetime of a radiometer, though the annual rate of degradation is rather small, typically less than 1% per year. Often, a significant correlation between the gain and temperature of a radiometer is observed. Degradation of sensor's sensitivity reduces the radiometric resolution of AVHRR measurements and expands the upper limit of a measured brightness temperature. PRT measurements are subject to significant orbital variation (up to 7 K) and inconsistency for some AVHRR radiometers. The inconsistency was especially large for AVHRR onboard NOAA-12 (up to 4 K) and NOAA-14 (up to 3 K). It is less than 0.5 K for NOAA-15 and -16. The inconsistency may signify the existence of a thermal gradient across the ICT. Some systematic differences between PRT may also indicate inaccurate characterization of PRT sensors, for example for AVHRR/NOAA-11 and –14.

Fraser, R., and Z. Li, 2002, Estimating fire related parameters in boreal forest using SPOT VEGETATION, *Rem. Sens. Environ*., in press.

The majority of burning in the boreal forest zone consists of stand replacement fires larger than 10 km^2 occurring in remote, sparsely populated regions. Satellite remote sensing using coarse resolution (≈1 km) sensors is thus well suited to documenting the spatial and temporal distribution of fires in this zone. The purpose of this study was to investigate the utility of the SPOT VEGETATION (VGT) sensor for estimating three key parameters related to boreal forest fire: burned area, post-fire regeneration age, and aboveground biomass. Based on a sample of fires across Canada, the best overall discrimination of burned forest was provided by a normalized vegetation index (SWVI) that combines near-infrared (NIR) and short-wave infrared (SWIR) channels from VGT. Multi-temporal differencing of this index from anniversary date VGT composites was combined synergistically with active fire locations from NOAA/AVHRR to map Canadian forest that burned during 1998 and 1999. National burned area estimates for both years were within 15% of those compiled by the Canadian Interagency Forest Fire Centre. The normalized index also was correlated (R=0.68) with the age of regenerating forests in Saskatchewan and Manitoba that burned between 1949-1998. An artificial neural network model developed using temporal metrics computed from VGT could predict the age of these forests with a RMS error of seven years (R=0.83). By contrast, forest biomass derived from Canada's Forest Inventory was estimated with relatively poor accuracy (RMS=32 t/ha) from VGT reflectance and terrestrial ecozone using a network model. We conclude that the VGT instrument is effective for mapping large boreal burns at the end of a fire season and approximating the age of regenerating burns less than about 30 years old. This information can be useful to supplement conventional ground-based data sets in remote areas where coverage may be incomplete.